

REMARKS

Claims 1-50 are pending. In the Office Action dated January 18, 2007, the Examiner took the following action: (1) rejected claims 1-18, 23-31 and 36-44 under 35 U.S.C. § 112, second paragraph, as failing to distinctly claims the subject matter; (2) rejected claims 1, 3-6, 10-11, 13-15, 19 and 22 under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,880,117 to Lin et al. (“Lin”); (3) rejected claims 2, 9, 12, 16-17, 20-21, 23 and 32 under 35 U.S.C. § 103(a) as being unpatentable over Lin; and (4) rejected claims 7-8, 24-31 and 33-35 under 35 U.S.C. § 103(a) as being unpatentable over Lin in view of U.S. Patent No. 5,621,739 to Sine et al. (“Sine”).

Applicant wishes to express his thanks to Examiners Siddiqui and Decayd for their time and courtesy in conducting a telephone interview with applicant’s attorney on March 19, 2007. During the interview, applicant’s attorney pointed out that the Lin *et al.* patent, which serves as the sole basis for the anticipation rejections of the independent claims, does not disclose altering over a range the relative timing between signals that are applied to a memory device, nor does it disclose altering the frequency over a range of a clock signal applied to a memory device. During the interview, the Examiners pointed out that the Lin *et al.* patent did teach the concept disclosed in the application of coupling two signals to a memory device, which would constitute a single timing relationship in a range, but the Examiner’s were unable to show any place in the Lin *et al.* patent where the concept of *altering* this timing relationship. The Examiners also pointed out that the Lin *et al.* patent disclosed a clock signal generated from a CLOCK1 signal that had a frequency of twice the frequency of the CLOCK1 signal. However, the Examiners were unable to find any teaching in the Lin *et al.* patent of the function performed by applicant’s disclosed embodiment of applying a clock signal to a memory device and altering the timing of the clock signal as various memory operations are performed to see if the device would properly operate over this range of clock signal frequencies.

The disclosed embodiments of the invention will now be discussed in comparison to the applied references. Of course, the discussion of the disclosed embodiments, and the discussion of the differences between the disclosed embodiments and the subject matter described in the applied references, do not define the scope or interpretation of any of the claims. Instead, such discussed differences merely help the Examiner appreciate important claim distinctions discussed thereafter.

The disclosed invention is a memory module having a plurality of memory devices and a memory hub that is used to access the memory devices, as well as a processor-based system using the memory module and a method carried out by the memory module. The memory hub includes a self-test module coupled to the memory devices. The self-test module couples first and second corresponding signals to at least one of the memory devices. In one of the disclosed examples, the first and second signals are a write data strobe signal and a write data signal. The self-test module further receives output signals from the memory device being tested, and determines based on the received output signals whether the memory device has probably responded to the first and second signals. In one of the disclosed examples, the received output signals are read data signals. The disclosed self-test module is capable of testing the timing margins of the memory devices because the module is able to alter the relative timing between coupling at least some of the first and second signals to the memory device being tested. Similarly, the self-test module can alter the relative timing between when some of the first signals received from a memory device are used to latch corresponding ones of the second signals coupled from a memory device being tested to evaluate the operation of the memory device. In other embodiments, the memory hub includes a variable frequency clock generator, and the self-test module is able to generate a frequency control signal to alter the frequency of the clock signal during a test of a memory device.

The primary reference cited in the Office Action is the patent to Lin *et al.*, which discloses a memory device testing system 20 including a tester 22 connected to a single memory device 26. As shown in Figure 2, the memory device 26 may include a plurality of memory banks 50a-c. The tester 22 applies signals to the memory device 26 to write a pattern of data to the memory device, and it also applies signals to the memory device 26 to read data from the memory device 26. The read data is compared to the write data to determine if the memory device is operating properly. However, the tester 22 is not included in a memory hub, and, fact, is not even part of a memory module that includes the memory device 26. Furthermore, the tester 22 does not alter over a range the relative timing between when signals are applied to or receives from the memory device 26. Nor does the tester 22 alter over a range the frequency of a clock signal or alter over a range the timing that one signal received from a memory device is used to latch another signal received from the memory device.

According to the Office Action, the Lin *et al.* patent teaches a memory module, but the Office Action does not identify the module by reference numeral or indicate where in the specification a memory module is described. The Office Action also indicates that Lin *et al.* teach a plurality of memory devices (“Figure 2 #50A-c”), but the Lin *et al.* patent describes and shows in Figure 2 a single memory device 26 containing multiple memory banks 50A-C. Multiple memory banks are different from multiple memory devices. The Office Action also states that the Lin *et al.* patent teaches altering the relative timing between when some of the corresponding first and second signals in the series are coupled to the memory device (“Figure 1 #24”). However, reference numeral 24 of Figure 1 is a frequency multiplier circuit that simply generates a CLOCK signal that “is preferably and integer multiple of the frequency of the CLOCK1 signal” that is applied to the input of the frequency multiplier circuit 24. [Column 5, line 34-35]. Nowhere in the Lin *et al.* patent is there any statement or suggestions that the frequency of the CLOCK signal is varied during a test.

Turning, now, to the claims, claim 1 is directed to a memory module comprising a plurality of memory devices and a memory hub. The memory hub includes, *inter alia*, a self-test module that is operable to couple a series of corresponding first and second signals to at least one memory device in the module. The self-test module is further operable to alter the relative timing between when some of the corresponding first and second signals in the series are coupled to the memory device. The self-test module then receives output signals from the memory device, and determines based on the signals whether the memory device properly responded to the first and second signals. As explained above, the Lin *et al.* patent does not disclose a memory hub included in a memory module that alters over a range the relative timing between when first and second signals are applied to a memory device. To support an anticipation rejection of a claim, the cited reference must disclose each and every element of the claim exactly as specified in the claim. The Lin *et al.* patent clearly does not disclose each and every element of claim 1. Claim 1 is therefore novel over the Lin *et al.* patent.

The memory module of claim 1 is specified in the context of a processor-based system in claim 23 and therefore patently distinguishes over the Lin *et al.* patent for the reasons explained above.

Claim 11 is also directed to a memory module contain a plurality of memory devices and a memory hub. Claim 11 specifies that the memory hub includes, *inter alia*, a self-

test module that receives first and second signals from a memory device and uses the first signals to latch corresponding ones of the second signals. The claim further specifies that the self-test module is operable to alter over a range the relative timing between when some of the first signals are used to latch the corresponding second signals. The latched second signals are then used to evaluate the operation of the memory device. As explained above, the testing circuits shown in the cited references do not disclose a memory hub that includes any means for altering the relative timing between which signals received from a memory device are latched. Claim 11 is therefore not anticipated by the Lin *et al.* patent.

Claim 19 is directed to a memory module containing a plurality of synchronous memory devices and a memory hub. The memory hub includes, *inter alia*, a variable frequency clock generator that couples to a memory device a clock signal having a frequency corresponding to a frequency control signal. The memory hub also includes a self-test module that generates the frequency control signal to vary the frequency of the clock signal over a range during a test. The self-test module couples a first series of input signals to the memory device. The self-test module then receives output signals from the memory device and uses these output signals to determine whether the memory device properly responded to the series of first signals as the frequency of the clock signal is varied. As explained above, the Lin *et al.* patent does not disclose a memory hub containing any circuitry that alters the frequency of a clock signal applied to a memory device during testing of the memory device. Claim 19 is therefore novel over the Lin *et al.* patent.

The memory module of claim 19 is specified in the context of a processor-based system in claim 32 and therefore patently distinguishes over the Lin *et al.* patent for at least the same reasons that claim 19 is novel.

Claim 36 is directed to a method of performing signal timing testing on a memory system having a memory hub coupled to a plurality of memory devices. The method includes generating testing signals in the memory hub that are coupled to the memory devices while the relative timing between the testing signals is varied. Output signals from the memory device that result from the testing signals are generated and coupled to the memory hub. These output signals are then evaluated in the memory hub to determine if the memory devices properly responded to the testing signals. As explained above, the Lin *et al.* patent does not disclose a

method of testing a memory device in which the relative timing between signals applied to the memory device is varied. Claim 36 is therefore clearly patentable.

Claim 42 is directed to a method of performing signal timing testing on a memory system having a memory hub coupled to a plurality of memory devices. The method includes generating write data and data strobe signals for each of a plurality of memory operations. The write data are stored in the memory hub and are then coupled to a memory device along with the data strobe signal for each of a plurality of write memory operations. However, the relative timing between the write data and the data strobe signal is altered in at least some of the write memory operations. The write data coupled from the memory hub are stored in the memory devices and subsequently read by coupling read data from the memory devices to the memory hub. The memory hub compares the read data coupled from the memory devices to the write data coupled to the memory devices. As explained above, the Lin *et al.* patent does not disclose a memory hub that alters the relative timing between signals coupled to a memory device, and it certainly does not suggest altering the relative timing between write data and a data strobe signal coupled to a memory device. Claim 42 is therefore not anticipated or obvious in view of the Lin *et al.* patent.

Claim 44 is also directed to a method for performing signal timing testing on a memory system having a memory hub coupled to a plurality of memory devices. The method includes generating in the memory hub a memory command and a clock signal for each of a plurality of memory operations. In at least some of the memory operations, the relative timing between coupling the memory command and the clock signal to the memory device is altered. A memory operation is then performed in the memory device for each of the plurality of memory commands. Data are then read from the memory device by coupling read data from the memory devices to a memory hub in each of a plurality of read data operations. The memory hub then uses the read data to determine if the memory devices properly performed the memory operations corresponding to the memory commands. As explained above, the Lin *et al.* patent does not disclose or suggest a memory hub that alters the relative timing between signals coupled to a memory device, and they certainly do not suggest altering the relative timing between memory commands and a clock signal coupled to a memory device. Claim 44 is therefore patentable over the cited references.

Claim 45 is directed to a method for performing signal timing testing on a memory system having a memory hub coupled to a plurality of memory devices. The method includes generating in the memory hub a clock signal having a variable frequency. The clock signal and test signals for each of a plurality of memory operations are then coupled from the memory hub to the memory devices while the frequency of the clock signal is altered for at least some of the memory operations. The memory devices respond to the test signals, and read data stored in the memory devices are coupled to the memory hub during each of a plurality of read operations. The memory hub then uses the read data to determine whether the memory devices properly performed the memory operations corresponding to the test signals. As explained above, the Lin *et al.* patent does not disclose coupling a clock signal and test signals from a memory hub to memory devices while the frequency of the clock signal is altered. Instead, the clock signal generated by the Lin *et al.* patent device has a frequency that is fixed during a test.

Applicant requests reconsideration of the Section 112 rejection. As discussed during the interview, the “relative timing” between two signals simply means that the timing of one signal with respect to the timing of the other signal is varied. In this context, there is therefore nothing indefinite about the term “relative timing.”

All of the claims in the application, *i.e.*, claims 1-50, are clearly allowable. Favorable consideration and a timely Notice of Allowance are therefore earnestly solicited.

Respectfully submitted,
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